

We Claim:

1. An apparatus for injecting steam from a wellbore into a geological formation, the apparatus comprising:
a flow path between a well surface and the formation, the flow path including
5 at least one nozzle, the at least one nozzle including a throat portion and a diffuser portion, whereby the steam will flow through the nozzle at a critical flow rate.
2. The apparatus of claim 1, wherein the apparatus injects steam from a lateral wellbore into the formation.
- 10 3. The apparatus of claim 1, wherein the critical flow rate is a controlled flow rate.
4. The apparatus of claim 3, wherein the flow path includes a string of tubulars
15 extending from the well surface to the formation, the at least one nozzle located in the string of tubulars, proximate the formation.
5. The apparatus of claim 4, wherein the fluid path further includes a fluid path formed in a wall of a casing lining the wellbore, the fluid path formed adjacent the
20 formation.
6. The apparatus of claim 5, wherein the fluid path formed in the casing includes perforations.
- 25 7. The apparatus of claim 4, further including at least one opening formed along the string of tubulars proximate the formation, the at least one nozzle connected to the at least one opening.
8. The apparatus of claim 7, wherein the at least one opening includes an
30 enlarged area or a pocket.

9. The apparatus of claim 8, wherein the enlarged area is disposed circumferentially around the string of tubulars.

10. The apparatus of claim 9, wherein a portion of the string of tubulars within the enlarged area has apertures disposed therein which are circumferentially distributed around the string of tubulars.

11. The apparatus of claim 10, wherein the number of apertures in the tubular string is variable and selectable.

12. The apparatus of claim 11, further including an intermediate sleeve member disposable in the tubular string adjacent the apertures in the wall, the intermediate sleeve member having circumferentially distributed apertures alignable with the apertures in the wall.

13. The apparatus of claim 12, wherein the apertures in the sleeve are constructed and arranged to permit steam to pass from the tubing to the pocket while maintaining a predetermined ratio of water and vapor.

14. The apparatus of claim 9, wherein at least two pockets are disposed along the tubular string.

15. The apparatus of claim 8, further including a wall between an interior of the tubing and the at least one opening, the wall having at least one aperture formed therein.

16. The apparatus of claim 15, wherein the number of apertures in the wall between the tubing and the pocket is variable and selectable.

17. The apparatus of claim 16, further including an intermediate sleeve member disposable in the tubular string adjacent the apertures in the wall, the

intermediate sleeve member having apertures alignable with the apertures in the wall.

18. The apparatus of claim 17, wherein the steam is saturated steam.

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19. The apparatus of claim 18, wherein the steam includes a component of water and a component of vapor.

20. The apparatus of claim 17, wherein the apertures in the sleeve are constructed and arranged to permit steam to pass from the tubing to the pocket while maintaining a predetermined ratio of water and vapor.

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21. The apparatus of claim 20, wherein the apertures in the wall between the tubing and the pocket are substantially perpendicular to a longitudinal axis of the tubing.

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22. The apparatus of claim 21, wherein the flow of fluid through the nozzle is approximately parallel to the longitudinal axis of the tubing.

23. The apparatus of claim 8, wherein there are at least two pockets disposed along the tubular string and an annular area between each pocket and an adjacent formation is isolated with a packing member.

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24. The apparatus of claim 8, wherein the nozzle is remotely removable.

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25. The apparatus of claim 8, wherein the nozzle is remotely insertable.

26. An apparatus for injecting steam at a controlled flow rate into a geological formation, the apparatus comprising:

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a flow path between a well surface and the formation, the flow path including at least one opening, the opening permitting steam flow at a critical flow rate with an

annulus/tubing pressure ratio of up to about 0.9 by using a throat and diffuser portion in the opening.

27. The apparatus of claim 26, further comprising an obstructing member
5 disposed across from the nozzle which urges the steam along the flow path into the formation.

28. A method of injecting steam into a geological formation comprising:
introducing the steam into a wellbore lined with casing, the wellbore including
10 at least one zone of interest and the casing having perforations adjacent the at least one zone; and

flowing the steam through a nozzle at a critical flow rate from a string of tubing to the perforations, the nozzle having a throat portion and a diffuser portion.

29. The method of claim 28, wherein the critical flow rate is maintained when an
15 annulus/tubing ratio is greater than about 0.56.

30. The method of claim 29, wherein the steam is introduced at a pressure
adequate to overcome a natural pressure and impermeability present in any of the at
20 least one zone of interest.

31. The method of claim 28, further including causing a flow of the steam through
the tubing whereby a water component of the steam travels in an annular fashion
along an inner wall of the tubing.

32. The method of claim 30, further including removing the nozzle and replacing it
25 with a second nozzle.

33. An apparatus for injecting steam at a controlled rate into multiple zones of
30 interest adjacent a wellbore, the apparatus comprising:

a tubular string for transporting steam into the wellbore from the surface of the well;

at least two nozzles disposed along the string, each nozzle located in that position of the wellbore adjacent a first and second zones of interest, the nozzles having a throat portion and a diffuser portion.

5 34. The apparatus of claim 33, further including sealing means isolating an annular area above and below each nozzle, the annular area formed between the tubular and walls of the wellbore.

10 35. The apparatus of claim 33, further comprising an obstructing member disposed downstream from each nozzle, wherein the obstructing member hinders a portion of the fluid from flowing downstream in the preferential direction of each nozzle.

15 36. An apparatus for injecting steam into multiple wellbores from a single source of steam, the apparatus comprising:

a fluid path from the source of steam to each wellbore; and

at least one nozzle between the source and each wellbore, the at least one nozzle including a throat and a diffuser portion providing a predetermined flow rate of steam to each wellbore.

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37. An apparatus for injecting steam from a source of steam to at least two wellbores, the apparatus comprising:

a flow path for the steam between the source of steam and the at least two wellbores;

25 at least one nozzle in the flow path, the nozzle for controlling a flow of steam using critical flow.

38. The apparatus of claim 37, wherein there are an equal number of nozzles and wellbores.

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39. The apparatus of claim 37, wherein the at least one nozzle includes a throat portion and a diffuser portion.

40. An apparatus for injecting steam into a lateral wellbore comprising:
a tubular string;
at least one pocket formed circumferentially around the tubular string; and
5 at least one nozzle disposed on the tubular string, the at least one nozzle
including a throat portion and a diffuser portion.

41. The apparatus of claim 40, further comprising at least one aperture in the
tubular string to provide fluid communication between the inner diameter of the
10 tubular string and the at least one pocket.

42. The apparatus of claim 41, further comprising a plurality of apertures
disposed circumferentially around the tubular string to provide fluid communication
between the inner diameter of the tubular string and the at least one pocket.

15 43. The apparatus of claim 42, further comprising at least one sleeve member
disposable in the tubular string adjacent the plurality of apertures, wherein the at
least one sleeve member comprises a plurality of apertures disposed
circumferentially therearound.

20 44. The apparatus of claim 43, wherein the plurality of apertures in the at least
one sleeve member are alignable with the plurality of apertures in the tubular string
to permit steam to flow from the tubular string to the at least one pocket to maintain
a predetermined ratio of water and vapor injected into a geological formation through
25 each of at least two nozzles.

45. The apparatus of claim 40, further comprising at least one obstructing member disposed on the tubular string across from the at least one nozzle.

- 5 46. The apparatus of claim 45, wherein the at least one obstructing member prevents a portion of the steam from flowing in a direction in which the steam is dispensed from the at least one nozzle.